PROC. R. SOC. VICT. vol. 97, no. 3, 151-155, September, 1985

FOOD OF INTRODUCED MAMMALIAN PREDATORS IN TWO VICTORIAN NATIONAL PARKS

By P. A. Woolley, J. A. Craik and G. L. Grossek

Department of Zoology, La Trobe University, Bundoora, Victoria 3083.

Abstract: The diets of introduced mammalian predators (foxes, dogs and cats) living in the Little Desert and Wyperfeld National Parks in north-western Victoria were studied by scat analysis to determine the extent of predation on native fauna. Food items included mammals, birds, reptiles, insects and other invertebrates, and plant material. Mammals appeared to be the most important food items with exotic species (*Oryctolagus cuniculus* and *Mus musculus*) occurring much more frequently than indigenous species. Only two (*Macropus fuliginosus* and *Trichosurus vulpecula*) of the 11 species of indigenous terrestrial mammals known to occur in the Parks made any significant contribution to the diet of the predators. Predation on birds and reptiles was generally low and, while insect and plant remains occurred frequently, the number of scats containing large quantities of either was low.

Studies such as that of Triggs, Brunner and Cullen (1984) on the diets of introduced mammalian predators (foxes, *Vulpes vulpes*; dogs, *Canis familiaris*; and, cats, *Felis catus*) have shown that they prey on both introduced and indigenous mammals, and a wide variety of other indigenous wildlife. Plant material is also eaten. The conclusion reached in most studies (e.g. McIntosh 1963, Coman & Brunner 1972, Croft & Hone 1978, Jones & Coman 1981, Woolley & Valente 1982) is that they are opportunistic predators and scavengers, feeding on whatever is abundant and easily available at the time. Thus in agricultural areas domestic stock (eaten mostly as carrion) may form a major component of the diet (McIntosh 1963, Coman 1973); whereas in areas containing no domestic stock introduced mammals such as the rabbit, *Oryctolagus cuniculus*, and the feral house mouse, *Mus musculus*, may form major components (Ryan & Croft 1974, Seebeck 1978). In bush areas where there are few rabbits or mice indigenous mammals may form an important component of the diet (Coman & Brunner 1972, Brunner, Lloyd & Coman 1975, Triggs *et al.* 1984). Control of introduced mammalian predators may therefore, depending on the availability of other foods, be desirable in National Parks to protect native fauna.

Following a suggestion by the Research Co-ordinator of the National Parks Service of the Department of Conservation, Forests and Lands, a study of the diet of introduced mammalian predators in the Little Desert and Wyperfeld National Parks was carried out to determine the extent of predation on native fauna. Diet was investigated by analysis of remains in scats. Foxes and feral dogs and cats are known to occur in both Parks.

STUDY AREAS

The Little Desert National Park (area 35,240 ha), in the heart of Victoria's wheat growing Wimmera district, was originally set aside to protect the Mallee Fowl. Predator scats were collected in the three most extensive vegetation types within the Park, *viz.* heathland, broombush shrubland and riverain woodland (Cheal, Day & Meredith 1979, Fig. 27), and in Crown Land adjoining the northern boundary of the Park.

Wyperfeld National Park (area 100,000 ha) was reserved to protect an area of typical mallee country. Scats were collected in heathland, mallee shrubland and riverain woodland, these being the most extensive vegetation types within the Park (Cheal *et al.* 1979, Fig. 28).

Scats were collected on walking tracks and roads in one or more areas within each vegetation type in each Park. The collecting localities are shown in Fig. 1 (Little Desert National Park) and Fig. 2 (Wyperfeld National Park). In each locality collections were made from 26 February to 5 March, 30 April to 3 May and 9 to 13 July 1979.

SCAT ANALYSIS

Each scat, or group of scats from a single dropping, was placed in a labelled envelope and oven-dried at 80°C for 48 hours to destroy the eggs of parasites. The scats were soaked individually in water for up to 48 hours to soften them. They were then broken up, poured into a 248 μm aperture sieve and washed. The remaining material was placed in a white enamel tray and sorted into the following categories: hair, feathers, scales, teeth, bones, egg shell, invertebrates and material of plant origin. The components were dried and, as far as possible, identified.

Hair was identified using the method described by Brunner and Coman (1974). Samples of hair from all species of terrestrial mammals known to occur in the Parks (Cheal *et al.* 1979, Table 32) were obtained from Museum collections and a reference collection of cross sections, whole mounts and scale casts of the hair of each species prepared. Hairs from the scats were identified by comparison with both the reference collection and the photographs in Brunner and Coman (1974).

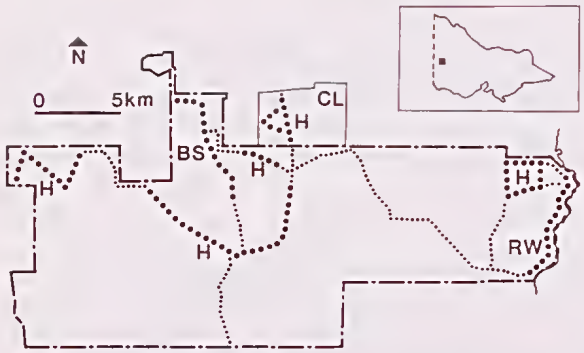

Fig. 1—The collecting localities in heathland (H), broombush shrubland (BS) and riverain woodland (RW) in Little Desert National Park. CL = Crown Land.

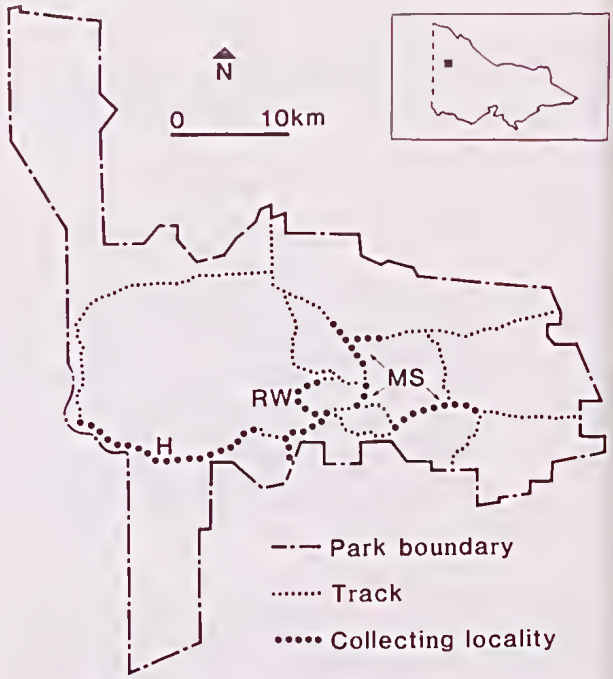

Fig. 2—The collecting localities in heathland (H), mallee shrubland (MS) and riverain woodland (RW) in Wyperfeld National Park.

RESULTS

A total of 923 scats was collected in the Little Desert National Park (LDNP) and 882 in Wyperfeld National Park (WNP). Similar numbers were obtained in each collecting period in each Park. Most were judged, on the basis of appearance and/or odour, to be from foxes. Fox scats have a characteristic 'tail', formed by the drawing out of one or both ends of the scat (Burrows 1968), and fresh ones have a characteristic odour. Only 16 scats, collected in LDNP, were considered to be of cat origin. The possibility exists that some of the smaller 'fox' scats were from cats. Less than 1.5% of the scats collected in each Park (16 in LDNP, 11 in WNP) were considered, largely on the basis of size, to be from dogs. The number of scats in which each of six categories of food items were found, and the frequency of occurrence of these items in the total sample from each Park, are shown in Table 1.

The remains found most frequently in scats were of mammalian origin and consisted of either hair or bone or both. Of the scats containing mammal remains, 577 of 599 collected in LDNP and 537 of 650 collected in WNP contained hair and/or bones which permitted identification of the species eaten. Some scats contained the hair of more than one species. Most bone samples consisted of small pieces which were unsuitable for specific identification, but occasionally jaw bones, teeth and claws, which could be identified, were present. The frequency of occurrence of mammal species identified in scats is shown in Table 2. Bird remains consisted mostly of small pieces of egg shell and feathers, the barbs and barbules of which had been destroyed in the digestive processes; they could not be further identified. Reptile remains included skin, scales, bones, claws and an egg. The species recognised in scats from LDNP included *Varanus* sp., *Amphibolurus* sp., *Ctenotus* sp.,

TABLE 1
PERCENTAGE OCCURRENCE OF FOOD ITEMS IN SCATS COLLECTED IN THE LITTLE DESERT (LDNP) AND WYPERFELD (WNP) NATIONAL PARKS. N = NUMBER OF SCATS IN WHICH FOOD ITEM WAS FOUND.

	LDNP		WNP	
Food items	N	%	N	%
Mammals	599	64.9	650	73.7
Birds	135	14.6	42	4.9
Reptiles	26	2.8	33	3.7
Insects	346	37.5	363	41.2
Other invertebrates	35	3.8	3	0.3
Plant material	574	62.2	344	39.0
Total number of scats	923		882	

TABLE 2
PERCENTAGE OCCURRENCE OF REMAINS OF EXOTIC AND INDIGENOUS MAMMALS IN SCATS COLLECTED IN THE LITTLE DESERT (LDNP) AND WYPERFELD (WNP) NATIONAL PARKS. N = NUMBER OF SCATS IN WHICH SPECIES WAS FOUND.

	LDNP		WNP	
Mammalian species	N	%	N	%
EXOTIC				
Oryctolagus cuniculus	179	31.0	244	45.4
Mus musculus	133	23.0	147	27.4
Ovis aries	164	28.4	6	1.1
Capra hircus	3	0.5	0	0
Felis catus	7	1.2	0	0
Vulpes vulpes	5	0.9	0	0
Canis familiaris	2	0.3	0	0
INDIGENOUS				
Macropus fuliginosus	90	15.6	66	12.3
Trichosurus vulpecula	65	11.3	60	11.2
Sminthopsis crassicaudata	8	1.4	0	0
Antechinus flavipes	2	0.3	0	0
Ningaui sp.	0	0	1	0.2
Pseudomys apodemoides	11	1.9	27	5.0
Notomys mitchelli	9	1.6	6	1.1
Tachyglossus aculeatus	4	0.7	5	0.9
Total number of scats containing identifiable mammalian remains.	577		537	

Phyllodactylus marmoratus and *Tiliqua rugosa*. In scats from WNP *Varanus gouldii*, *Amphibolurus* sp., *Ctenotus* sp., *Tiliqua rugosa*, *Chelodina longicollis* and a juvenile of *Pseudonaja textilis* were found.

Identifiable insect remains were found in 180 of 346 scats from LDNP, and 293 of 363 from WNP. Many scats from both Parks contained only very small amounts of insect material; in LDNP insects made up a substantial part of the scat in only 33 instances and in WNP, only 46 contained no other food items. The orders and families of insects represented, and the number of scats in which they were found, are shown in Table 3. The most commonly occurring insects were carabids and tenebrionids in LDNP, and blattids, tenebrionids and gryllids in WNP. Invertebrates other than insects occurred infrequently and included spiders, scorpions and centipedes.

Plant material, including twigs, leaves, grass, fruit and seeds, was found frequently in scats but often in only small amounts, especially in LDNP. There, only 57 of the 574 scats containing plant material included a large amount, and identifiable remains were found in only 73 scats. In WNP 309 of 344 scats contained identifiable plant material, 149 with large quantities. The plant species identified, and the number of scats in which they were found, are shown in Table 4. The most commonly occurring species were *Gyrostemon australasicus* in LDNP scats, and *Solanum simile* and *Billardiera cymosa*, in WNP scats.

Scats were collected in each of three periods (between late February and mid-July) and three vegetation types in

TABLE 3
THE OCCURRENCE OF INSECT REMAINS IN SCATS COLLECTED IN THE LITTLE DESERT (LDNP) AND WYPERFELD (WNP) NATIONAL PARKS.

	Number of scats	
Insects	LDNP	WNP
O. Coleoptera		
F. Carabidae	97	11
Tenebrionidae	46	59
Cerambycidae	3	0
Cantharidae	1	13
Histeridae	1	1
Silphidae	1	10
Scarabaeidae	0	24
O. Orthoptera		
F. Tettigoniidae	21	0
Gryllotalpidae	6	19
Gryllidae	1	59
O. Hymenoptera		
F. Formicidae	2	0
O. Dermaptera		
F. Forficulidae	2	0
O. Diptera		
F. Tachinidae	13	0
O. Hemiptera		
F. Reduviidae	0	1
O. Mantodea	1	7
O. Blattodea	0	137
O. Odonata	2	0
O. Lepidoptera	2	0
O. Isoptera	1	0

TABLE 4
THE OCCURRENCE OF PLANT MATERIAL IN SCATS COLLECTED IN THE LITTLE DESERT (LDNP) AND WYPERFELD (WNP) NATIONAL PARKS.

Plants	Number of scats LDNP	WNP
Gyrostemon australasicus	30	2
Leucopogon cordifolius	9	5
Leptospermum myrsinoides	9	0
juniperinum	2	0
coriaceum	0	2
Medicago minima	4	4
Astroloma conostephioides	2	0
Eucalyptus leucoxylon	1	0
camaldulensis	1	1
baxteri	6	0
largiflorens	0	1
incrassata	0	1
sp.	0	8
Casuarina paludosa	2	0
luehmannii	0	4
Lepidobolus drapetocoleus	1	0
Hibbertia stricta	1	0
Solanum sinile	0	188
Bromus sp.	1	7
Danthonia sp.	0	1
Triticum aestivum	3	0
Hordeum sp.	4	0
Billardiera cymosa	0	119

the two Parks. A full seasonal comparison cannot be made, and it is not known if the scats collected in each vegetation type contained only food items eaten there, but little variation in the occurrence of various categories of food items was evident. The variations that were seen were consistent with expected seasonal changes in the abundance of the particular species or with known habitat preferences. For example, insect and reptile remains were less frequent in scats collected in winter (July) than in the two earlier collections; and the remains of *Trichosurus vulpecula*, a species largely dependent on trees for nest sites, were found most commonly in scats collected in riverain woodland. An increase in remains of *Mus musculus* in the third collection from WNP coincided with the beginning of a mouse plague (I. Norman pers. comm.).

DISCUSSION

Although it was not possible to determine with certainty the specific origin of the predator scats collected in this study, we consider that the majority were from foxes and that the results of scat analysis largely reflect the foods eaten by this predator. The range of food items found in the scats, and the percentage occurrence of each category, are in general accord with the results of studies on the diet of foxes carried out by others (e.g. McIntosh 1963, Coman 1973, Brunner *et al.* 1975). The most frequently occurring items found in the scats were the remains of mammals, insects and plants, with more scats containing mammal remains than other items. Mammals probably constitute the major food item, as the total number of scats containing large quantities of either insect or plant material was low. Birds (except in LDNP), reptiles and invertebrates other than insects occurred infrequently.

The mammalian remains found most frequently in scats were those of exotic species, in particular the rabbit (*Oryctolagus cuniculus*) and the house mouse (*Mus musculus*) both of which are known to occur commonly in the two Parks. The remains of sheep (*Ovis aries*), which occur in high densities around the Park, were also commonly found in scats from LDNP. Sheep may wander into the Park, or predators may move out to feed. Sheep are probably eaten as carrion, an assumption supported by the finding of dipterous pupae in association with wool in some scats.

Indigenous mammals found most frequently in scats were the Western Grey Kangaroo (*Macropus fuliginosus*) and the Brush Tail Possum (*Trichosurus vulpecula*). Large carcasses such as those of kangaroos may provide predators with many meals and once the hide is eaten the carrion may not be readily detected in scats. This problem may account for the large number of scats with unidentifiable mammalian remains (mostly bone) in the WNP collection. Kangaroo carcasses were seen frequently in heathland in WNP and many scats collected there contained unidentifiable bone material. *Macropus rufogriseus*, which is known to occur in LDNP, was not detected in any scats.

Small indigenous rodents (*Pseudomys apodemoides* and *Notomys mitchelli*) and marsupials (*Sminthopsis crassicaudata*, *Antechinus flavipes* and *Ningaui* sp.), roughly comparable in size to house mice, were of infrequent occurrence in the scats and another two species (*Cercartetus concinnus* and *Sminthopsis murina*) known to occur in the Parks were not detected. The low frequency of occurrence of small indigenous mammals in the scats may reflect low densities of these animals in the Parks, or that these species may not be preferred prey items of foxes.

The level of predation on birds may be underestimated because scats were not collected in spring when the eggs and nestlings of ground nesting species would be vulnerable. The presence of shell fragments in some scats indicates that eggs are taken; and Frith (1962), in a study carried out in New South Wales, reported that predation by foxes on Mallee Fowl eggs (but not adult birds) was high. No explanation for the difference in levels of predation on birds in the two Parks is obvious.

At the time this study was carried out foxes were probably the major mammalian predators in both Parks. As in other areas where the diet of foxes has been studied, their preferred food items, in the absence of domestic stock, appear to be exotic mammals such as rabbits and house mice. While these species continue to be abundant in the Parks, the level of predation on native fauna will presumably remain relatively low and the need for control of predators unimportant. The

presence of foxes may be of value in controlling the numbers of rabbits and house mice in the Parks.

ACKNOWLEDGEMENTS

We wish to thank the Director of National Parks, Mr J. D. Brookes, for granting research permits (numbers 789/43 and 789/44); the Research Coordinator, Mr A. Heislers, for valuable advice; and Park Rangers, Mr C. Brownsea and Mr J. Miller, for assistance in the selection of collecting localities. Mr I. Norman (Department of Agriculture) provided information on mouse numbers. Miss J. Dixon kindly allowed us to obtain hair samples from mammals in the collection of the Museum of Victoria. For assistance in the identification of items in scats we thank Mr H. Brunner and Mr A. Valente (hair), Mr P. A. Rawlinson (reptiles), Dr W. Dan-thanarayana (insects) and Mr P. D. Cheal and Mr A. Hall (plants).

REFERENCES

Brunner, H. & Coman, B. J., 1974. *The Identification of Mammalian Hair.* Inkata Press, Melbourne.

Brunner, H., Lloyd, J. W. & Coman, B. J., 1975. Fox scat analysis in a forest park in south-eastern Australia. *Aust. Wildl. Res.* 2: 147-154.

Burrows, R., 1968. *Wild Fox.* David and Charles, Newton Abbot.

Cheal, P. D., Day, J. C. & Meredith, C. W., 1979. *Fire in the National Parks of North-West Victoria.* National Parks Service, Melbourne.

Coman, B. J., 1973. The diet of Red Foxes, *Vulpes vulpes* L., in Victoria. *Aust. J. Zool.* 21: 391-401.

Coman, B. J. & Brunner, H., 1972. Food habits of the feral house cat in Victoria. *J. Wildl. Manag.* 36: 848-853.

Croft, J. D. & Hone, L. J., 1978. The stomach contents of foxes, *Vulpes vulpes*, collected in New South Wales. *Aust. Wildl. Res.* 5: 85-92.

Frith, H. J., 1962. Conservation of the mallee fowl, *Leipoa ocellata* Gould. *CSIRO Wildl. Res.* 7: 33-49.

Jones, E. & Coman, B. J., 1981. Ecology of the feral eat, *Felis catus* (L.), in south-eastern Australia. 1. Diet. *Aust. Wildl. Res.* 8: 537-547.

McIntosh, D. L., 1963. Food of the fox in the Canberra district. *CSIRO Wildl. Res.* 8: 1-20.

Ryan, G. E. & Croft, J. D., 1974. Observations on the food of the fox, *Vulpes vulpes* (L.), in Kinchega National Park, Menindee, N.S.W. *Aust. Wildl. Res.* 1: 89-94.

Seebeck, J. H., 1978. Diet of the fox *Vulpes vulpes* in a western Victorian forest. *Aust. J. Ecol.* 3: 105-108.

Triggs, B., Brunner, H. & Cullen, J. M., 1984. The food of the fox, dog and cat in Croajingalong National Park, south-eastern Victoria. *Aust. Wildl. Res.* 11: 491-499.

Woolley, P. A. & Valente, A., 1982. The Dibbler, *Parantechinus apicalis* (Marsupialia: Dasyuridae): Failure to locate populations in four regions in the south of Western Australia. *Aust. Mammal.* 5: 241-245.